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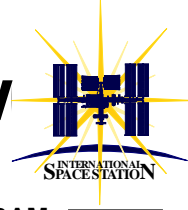


LAUNCH SERVICES PROGRAM

LSP Advisory Role for ISS Commercial Resupply Services



Commercial Resupply Contract Overview



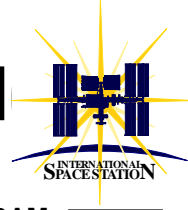
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- **The contract is a FAR Part 12 procurement (Commercial Item, firm fixed-price), the same as NLS.**
- **The period of performance is 2009 through 2015, with prices for 2016 to cover schedule slips.**
- **An end-to-end service is being procured:**
 - **This service includes mission integration, cargo integration, processing, launch, mission operations and cargo disposal or return.**
 - **ISS Program provides cargo at the bag or external Orbital Replacement Unit (ORU) level.**
 - **Houston commands the orbital vehicle during prox ops only.**
- **U.S. Commercial Provider of Space Transportation Services is required.**
- **AS9100 compliance is required.**



Commercial Resupply Services Procured



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CLIN 1: Standard Resupply Service, purchased by the kilogram

- 20 metric ton minimum upmass
- Internal upmass and disposal
- External upmass and disposal
- Internal upmass and return

CLIN 2: Non-Standard Services, purchased by the item

- Specifically for launch vehicle insight
- Data fulfills most needs for Category 2 LV Certification
- Detailed descriptions are in Back-Up charts

CLIN 3: Special Task Assignments, purchased by the hour

- Hourly rate for special efforts, more likely Station-related than LV-related



ISS Cargo Demand Fulfilled by CRS

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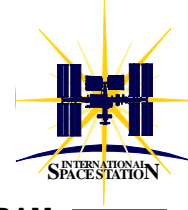
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This demand is in addition to US Cargo on ATV, HTV, and Progress.

| | CY10 | CY11 | CY12 | CY13 | CY14 | CY15 | total |
|--|------|------|------|------|------|------|-------|
| Internal Upmass – Customer Cargo (MT) | 2.7 | 4.8 | 6.7 | 6.2 | 11.0 | 8.2 | 39.6 |
| External Upmass – Usable Cargo (MT) | 0.0 | 1.8 | 1.1 | 2.2 | 1.3 | 2.0 | 8.3 |
| Return Downmass – Customer Cargo (MT) | 0.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 8.0 |
| Disposal Downmass – Customer Cargo (MT) | 1.5 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 26.5 |



CRS Launch Vehicle Responsibility



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- **Responsibility for Safety and Mission Success resides with each Contractor.**
- **The NASA Technical Authority for CRS missions will be the ISS Chief Engineer.**
- **The missions will use FAA-licensed commercial launches.**
- **LSP will not certify the launch vehicles.**
- **No NASA-chaired readiness reviews will be conducted for the launch vehicle.**
- **Neither ISS Program nor LSP has go/no-go authority on launch day.**
- **NASA will not be accountable for, have involvement in, or have control of the launches.**
- **CRS Mission Success payment is 20%.**
 - **NLS uses 10%.**



CRS Insight and Oversight Strategies

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- **SOMD AA directed a reduced level of insight for ISS Resupply.**
- **Key interface is the Cargo Bag or ORU to Orbital Vehicle, rather than our standard Spacecraft to Launch Vehicle.**
- **Requirements documents for verification:
SSP 50808 COTS IRD (Station to Orbital Vehicle interface),
SSP 50833 Cargo IRD (Cargo to Orbital Vehicle interface).**
- **ISS Program will CoFR that ISS is ready to accept the vehicle and that the Contractor has satisfied and met all contractual requirements.**
 - Includes the demonstration missions that berth at the ISS.
 - Berthing is the only planned attachment mode for CRS (or COTS).
- **Contractor's Orbital Vehicle is treated similarly to an International Partner's HTV, ATV or Progress.**
 - The CRS contract uses the same liability cross-waiver language as International Partner agreements.

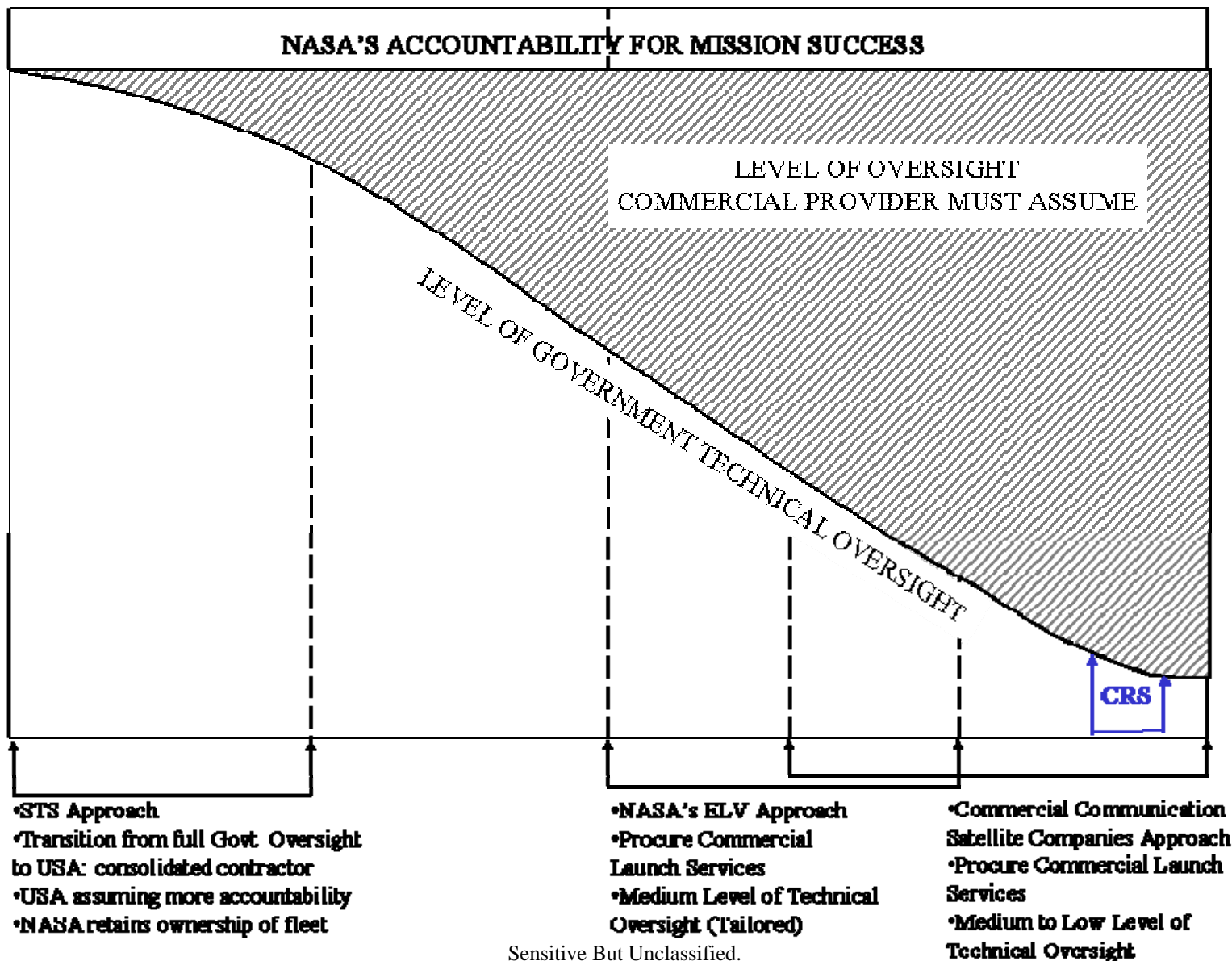


Oversight Spectrum for Launch Vehicles



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Sensitive But Unclassified.



LSP Insight: Applicability of NPD 8610



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- **NPD 8610 permits Delivery On Orbit services, FAA-licensed launches and tailored technical insight.**
- **Bedell, Carney and Wood started from a clean sheet and added back some elements of our usual NPD 8610 work, using LSP experience and looking at causes of past launch vehicle failures.**
- **Lessons learned from LSP advisory role for GOES are widely applied.**
- **The proposed items map to a few 8610.7D certification areas but no certification will be accomplished or required.**
- **Many areas of 8610.23C Attachment A are retained as launch vehicle insight only; no NASA approvals are required. Remaining areas will likely be accomplished by the Contractor in its normal practice.**
 - » **Many areas of Attachment A approvals are moved to the Cargo to Orbital Vehicle interface and approval authority is retained by ISSP.**
 - » **Stoplight summary for the launch vehicles is provided in Back-Up charts.**



LSP Insight: What We Will Do For CRS



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- ***Test Like You Fly assessment on three key systems***
- ***Guidance, Navigation & Controls and Flight Software IV&V***
- ***Safety and Mission Assurance insight***
- ***Post Flight Data Review, including one FMV***
- ***Mission Unique Design Review ERBs***
- **These areas were approved at LSP PRCB in November 2007.**
- **It is expected that the products LSP will review are items that the Contractor will produce in its normal course of business.**
- **LSP will elevate residual launch vehicle technical risks to the ISS Technical Authority.**
- **Based on these items, LSP will provide a launch vehicle assessment in only these areas to the ISS Program at the Stage Operations Readiness Review, typically around L-1 month.**



Two Areas of Non-Recurring LV Insight



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Test Like You Fly reviews for Propulsion, Flight Controls and Separation Systems

- ***Non-recurring*** unless there are design or component changes.
- Similar to Test Like You Fly assessments for Atlas V and Taurus certification and Delta IV risk mitigation, but limited to these three systems.
- Any systems found to cause a failure will be added.
- Major vehicle upgrades and configuration changes will first be briefed by the Contractor at the ISS Standing Review Board.
- These reviews will have LSP ERBs.

Guidance, Navigation & Controls and Flight Software IV&V

- Implemented at the scope of the Atlas V Category 3 certification.

Data for both obtained soon after contract kick-off. Assessments due at the Cargo Integration Review at L-4 months.

Data Requirements Descriptions are in Back-Up charts.



Three Areas of Recurring LV Insight



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S&MA Insight

- Two S&MA personnel on site at the contractor's LV production facility
- Compliance audits if not AS9100 certified
- Production progress and risks
- Material review boards, problem reports, anomaly resolutions, nonconformances, failure analysis, test results, and acceptance and preship reviews
- LSP Engineering will not be responsible to review, assess or make recommendations from this insight.

Post-flight data review, including a single Flight Margin Verification ERB

- Our normal data review process will occur for all Taurus II and Falcon 9 missions, not just CRS.
- FMV ERB intended for each Contractor's final demonstration flight only.
- Full participation permitted in mission failure investigations.

Mission-unique design reviews

- Expectations of the Station Program and the Contractors are in discussions as whether these will be LSP ERBs.
- Mission uniques expected to be mostly first flight items after the initial flights.
- These ERBs will occur at the CRS technical reviews on the next page.

Pertinent clauses and Data Requirements Descriptions are in Back-Up charts.



CRS Mission Integration Flow

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Quarterly program reviews in conjunction with mission reviews.

Vehicle Baseline Review at L-18 months

- Establish launch and orbital vehicle configurations and environments to enable ISS Integration efforts.
- Analogous to an MUPDR.

Mission Integration Review at L-13 months

- Checks schedule progress to ensure that NASA resources should be committed to the mission.
- Analogous to an MUCDR.

Cargo Integration Review at L-4 months

- Checks schedule progress to ensure that NASA cargo should be turned over for packing into the spacecraft
- Analogous to a DCR.

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|------|------|------|------|------|------|
| Total Missions | 1 | 3 | 3 | 4 | 5 | 4 |
| Plus 4 Demo missions ("fleet insight") in 2009 and 2010 | | | | | | |

Description of each technical review is in Back-Up charts.



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CLIN 2: Non-Standard Services



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Specifically added to facilitate LSP Certification and to provide additional mission assurance options for the ISS Program.

- It is not currently anticipated that we will exercise these services under the CRS contract.**

Implemented in the CRS Contract using Taurus certification plan language.

- Coupled Loads Analysis IV&V**
- Thermal IV&V**
- Flight Design IV&V**
- EMI/C IV&V**
- Type I or Type II Manufacturing Process Audits**
- Flight Hardware Operations and Integrated Test Processes Audit**
- Ishikawa Fishbone**
- Launch Service Complex Review**

Description of the data required for each Non-Standard Service is in the Back-Up charts.



Comparison of CRS Role to Certification



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| Launch Vehicle Risk Category | Category 1 (High Risk) | Category 2 (Medium Risk) | | Category 3 (Low Risk) | | |
|---------------------------------|--|---|--|---|--|--|
| Payload Class NPR 8705.4 | D | C and D, Sometimes B | | A, B, C and D | | |
| | | Alternative 1 | Alternative 2 | Alternative 1 | Alternative 2 | Alternative 3 |
| Quality Management Systems | AS9100 or ISO 9001 Compliant | AS9100 Compliant | | | | |
| Flight Experience | No previous flights required, can use the first flight of a common launch vehicle configuration, instrumented to prove design verification and flight performance data | 1 successful flight of a common launch vehicle configuration, instrumented to prove design verification and flight performance data | 3 (minimum 2 consecutive) successful flights of a common launch vehicle configuration, instrumented to prove design verification and flight performance data | 14 consecutive successful flights of a common launch vehicle configuration, instrumented to prove design verification and flight performance data | 6 (minimum 3 consecutive) successful flights of a common launch vehicle configuration, instrumented to prove design verification and flight performance data | 3 (minimum 2 consecutive) successful flights of a common launch vehicle configuration, instrumented to prove design verification and flight performance data |
| | Post Flight Operations/Anomaly Resolution Process | | | | | |
| | Flight Data Assessment Process | NASA Flight Margin Verification | | | | |
| Design Reliability | NASA assessment of LSC Design Reliability | | | | | |
| Mfg & Ops & Systems Engineering | NASA Audits, Documented ICD Process | NASA Audits | | No Additional Certification Requirements | NASA Audits | |
| System Safety | FMEA for all safety critical components Prelim and Final Hazards Analysis Compliance with applicable Range Safety Requirements | Demonstrated Compliance with Applicable Range Safety Requirements | | | | |



Comparison of CRS Role to Certification



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| Launch Vehicle Risk Category | Category 1 (High Risk) | Category 2 (Medium Risk) | | Category 3 (Low Risk) | | |
|--|---|--|----------------------------------|--|----------------------------------|--|
| | | Alternative 1 | Alternative 2 | Alternative 1 | Alternative 2 | Alternative 3 |
| Test and Verification | Acceptance Test Plans in Place, Ground and End to End Tests Completed | Comprehensive Acceptance Test Results | NASA Design Certification Review | No Additional Certification Requirements | NASA Design Certification Review | Comprehensive Acceptance Test Results |
| Quality Systems/Process | NASA Audit | | | No Additional Certification Requirements | NASA Audit | |
| Flight Hardware & Software Qualification | Qualified Hardware for space application, testing complete | Series of NASA ERB's on Vehicle Subsystems | NASA Design Certification Review | No Additional Certification Requirements | NASA Design Certification Review | Series of NASA ERB's on Vehicle Subsystems |
| Launch Vehicle Analysis | Analysis Plan/Definition | Analysis Plan/Definition and NASA CLA IV&V | NASA IV&V | No Additional Certification Requirements | NASA IV&V | |
| Risk Management | Risk Plan, Mitigated and Accepted Technical and Safety Risks | | | | | |
| Integrated Analysis | None | | | | | Full Vehicle Fishbone |
| Launch Complex | None | NASA ERB | NASA Design Certification Review | No Additional Certification Requirements | NASA Design Certification Review | NASA ERB |



Orbital Overview

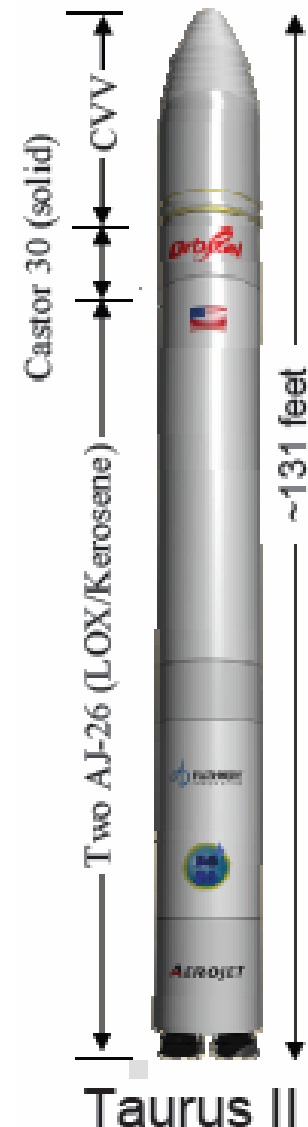
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Taurus II Launch Vehicle

- Claims 4800kg to the ISS orbit, 2000kg of ISS cargo.
 - Spacecraft is “Cygnus”/COTS Visiting Vehicle
- 1 COTS Demo mission December 2010.
- CRS missions: First mission is summer 2011, another in 2012. Two each in 2013, 2014 and 2015.
- First stage based off of Zenit, designed by Yuzhnoye, built by Yuzhmash, in Ukraine.
- First stage engine is the AJ-26-62.
 - Two NK-33s (AJ-26-58) joined together
 - Originally powered the Russian N-1 moon rocket
 - Have been stored for 35-40 years with a little recent testing
- Second stage is the Castor 30 solid motor from ATK.
 - IRAD nearly complete
 - Based on Castor 120
- Planned upgrade to LOX/Methane second stage in 2013.
 - PWR will supply the engine, a growth version of RL10.
 - Grows performance to 6200kg to ISS, 2700kg of ISS cargo.





SpaceX Overview

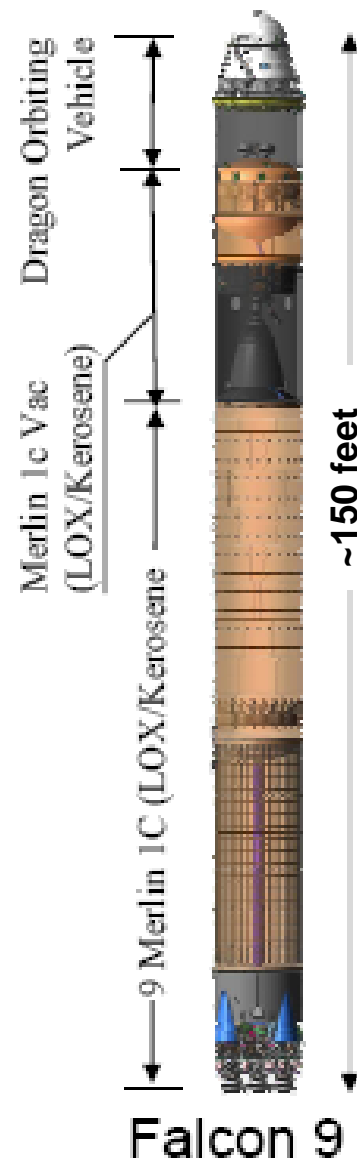
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Falcon 9 Launch Vehicle (Block 2)

- Claims 9300kg to the ISS orbit, 3300kg of ISS cargo.
 - Spacecraft is “Dragon,” designed for human rating.
 - Carries both internal and external cargo on one mission. Internal cargo return on every mission.
 - Cargo capacity is probably volume-limited.
- 3 COTS Demo missions (Block 1) total in 2009 & 2010.
- CRS missions: First mission is in late 2010. Two each in 2011, 2012, 2013 and 2015. Three in 2014.
- Two avionics strings, FS = 1.4, Engine-out from the pad.
- First stage is a 9-engine LOX/RP-1 stage.
- First stage engines are the Merlin 1C.
 - Pintle injector, Gas Generator cycle
- Second stage is a vacuum-optimized Merlin 1C-Vac.
 - Gas Generator exhaust provides roll control.





Off the Stage: Where to Find More Info



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Program Systems Integration Manager: Darren Bedell

- Handling LSP Space Act Agreements with all Contractors and strategic requirements for LSP CRS/COTS relationships
- Completing MOA with ISSP
 - » No new information other than onsite support at JSC (Lacey only) for up to one year
- Working on TTA for funding of Analex support to CRS
 - » PPBE submit in 2008 assumed only 1 new vehicle
 - » PPBE submit for 2009 will show 3 new vehicles (Falcon 9 Block 2, Taurus 2/Castor 30, Taurus 2/HESS)

Fleet Systems Integration Branch:

- Tom DeLaet (Falcon 9)
- Akash Vangani (Taurus II)

Flight Projects Office:

- Matt Lacey (detailed to VA-C, on site at JSC)
 - Working on a CRS implementation plan to define specific tasks and timelines
 - First revision will add protocols for interface with the ISS Program and CRS contractors
- Jim Hall (Back-Up MM at KSC)

<http://procurement.jsc.nasa.gov/issresupply>